Confocal Raman Imaging

WITec Raman Spectroscopy Solutions

www.witec.de

WITec UHTS

Ultra-High Throughput Spectrometers for Raman Microscopy

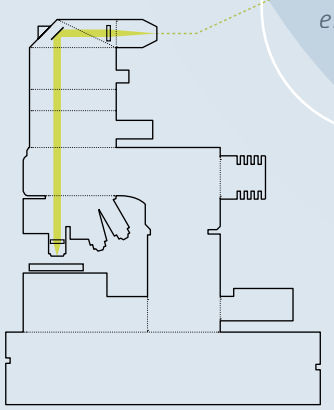
The WITec ultra-high throughput spectrometer (UHTS) series consists of exceptionally flexible and precise devices that meet the demands of cutting-edge confocal Raman imaging. For optimized performance, excitation sources, spectrometers, optics and cameras have to be carefully matched. The WITec UHTS design approach acknowledges this by employing a series of lens-based on-axis spectrometers with a choice of focal lengths, gratings and optics perfectly matched to the selected excitation wavelength. The spectrometers can be individually configured for specialized requirements and a wide variety of applications. No other manufacturer can provide such a high level of flexibility.

ULTRA-HIGH throughput

UHTS spectrometers are specifically designed for challenging Raman imaging and spectroscopy applications with intrinsically low light intensities.

ULTRA-FAST acquisition times

Using the UHTS for data collection, the acquisition time for a single Raman spectrum can be reduced to below one millisecond, providing essential benefits in confocal Raman microscopy where commonly thousands of Raman spectra must be acquired.



ULTRA-SHARP and symmetric peak shape

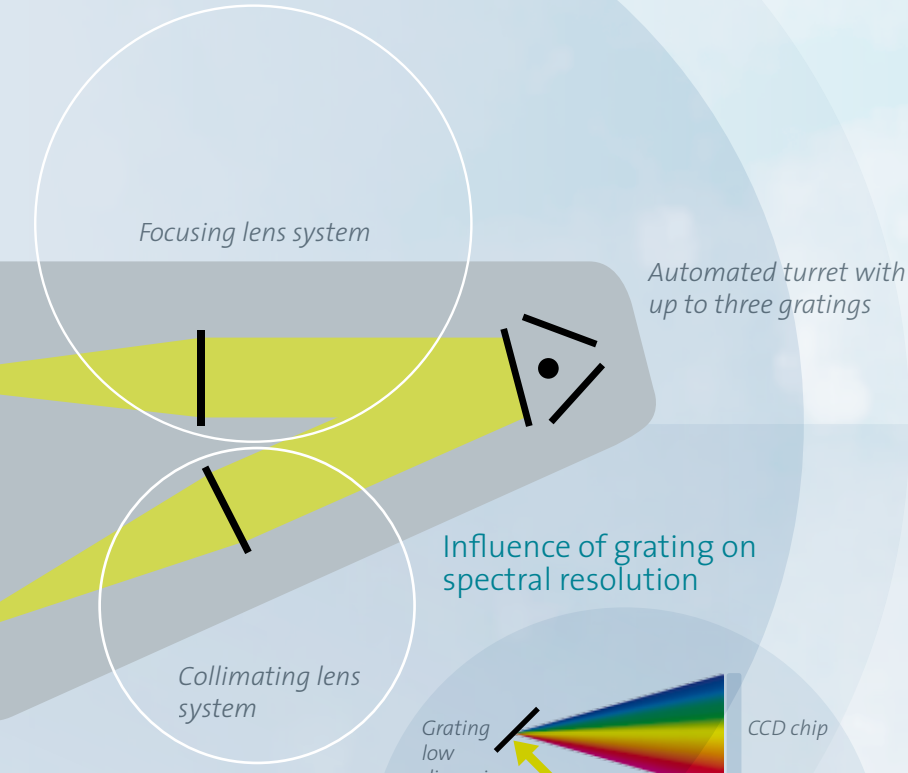
WITec UHTS spectrometers deliver outstanding spectral and imaging quality. Symmetric peak shapes are ensured by design with coma- and astigmatism-free optics.

ULTRA-CUSTOMIZABLE: triple-grating turret

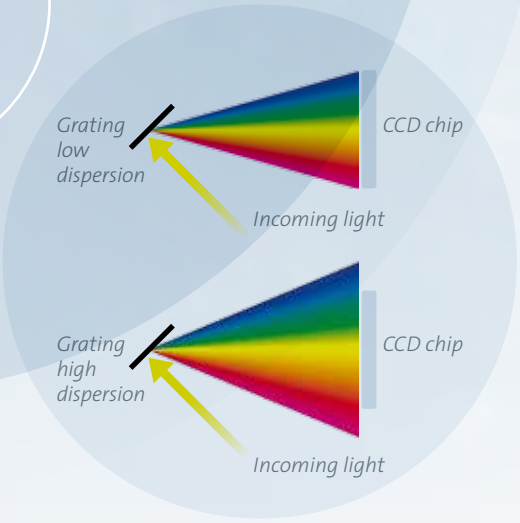
An automated three-grating turret facilitates the flexible integration and combination of individual gratings. Automated switching from one grating to another to accommodate varying experimental requirements has never been easier.

ULTRA-CONFIGURABLE: several focal lengths and grating types

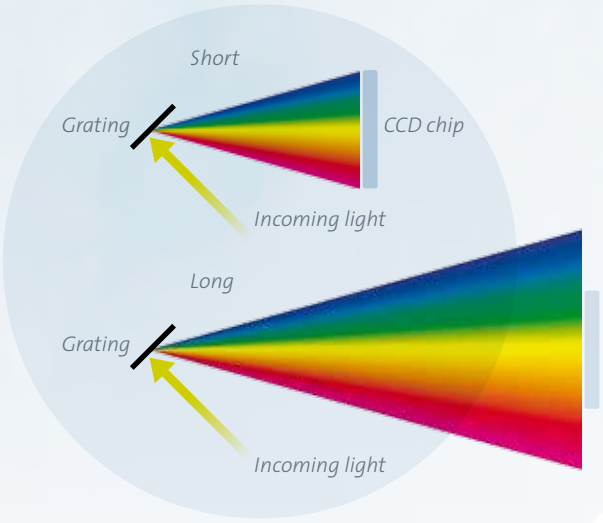
The Raman spectrometers of the UHTS series are available in different focal lengths to accommodate multiple laser excitation wavelengths and spectral resolution requirements for the most demanding Raman imaging experiments.



Influence of grating on spectral resolution



Influence of focal length on spectral resolution



Grating dispersion and focal length influence signal intensity, detectable spectral range and resolution.

Spectral and pixel resolution facts

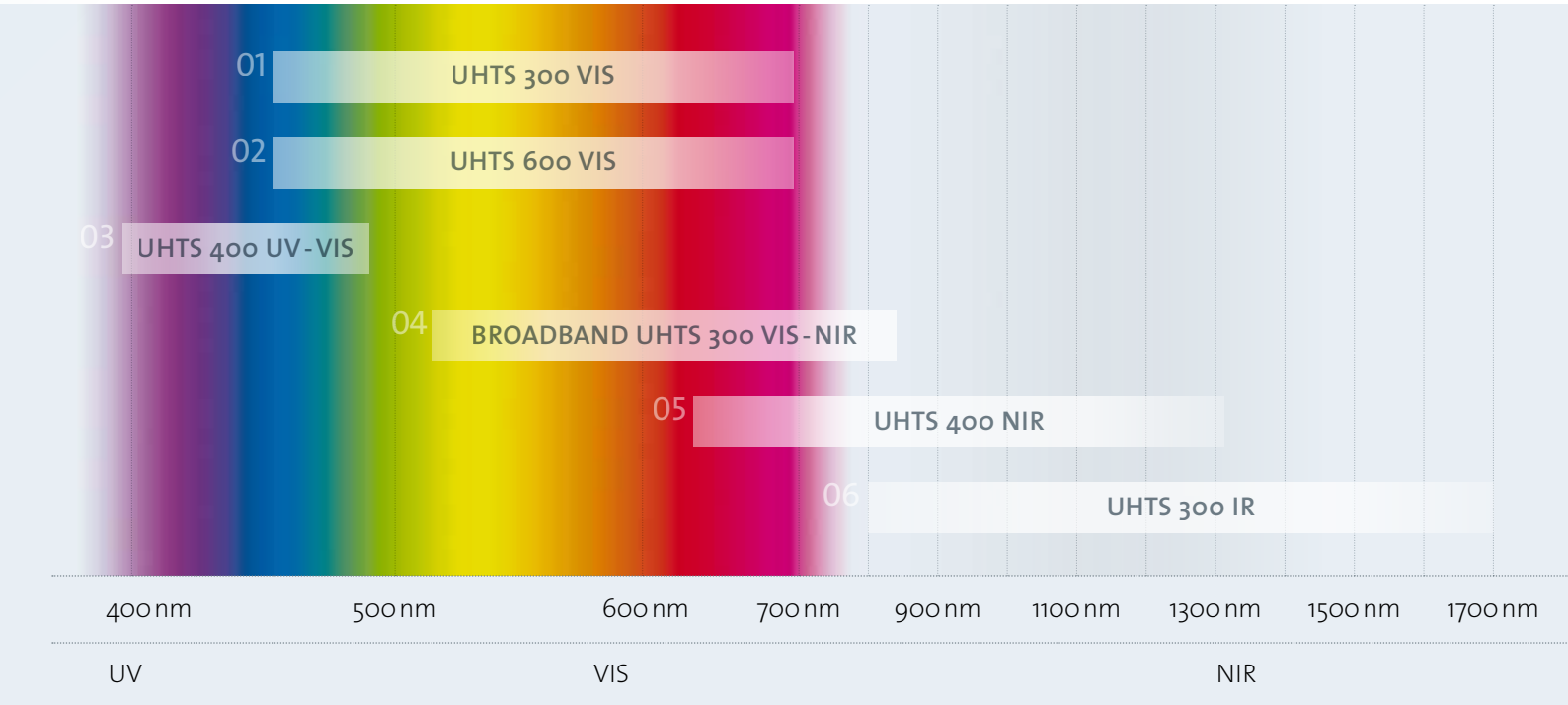
The resolving power of a spectroscopic system depends on focal length, grating groove density and pixel size of the CCD camera used for detection. The overall goal is to find the ideal balance with regard to acquisition time, signal-to-noise ratio and spectral resolution. Increasing the focal length or the number of grooves per millimeter on the grating increases the spectral resolution, but reduces the signal per pixel as the light is spread out over a larger area.

With the ultra-high throughput of the WITec spectrometer series, this signal loss is minimized and the full spectral bandwidth is retained through integrated spectral stitching procedures. As a result, highly-resolved spectra can be obtained from the full relevant spectral range up to a pixel resolution of 0.1 relative wavenumbers (cm^{-1}).

WITec UHTS Series

The lens-based spectrometers of the UHTS series allow for the highest throughput and are therefore suitable for high speed and high resolution Raman imaging. Gratings have their optimal reflectivity in only relatively small spectral ranges, leading to dramatic signal loss when used outside of those parts of the spectrum. Therefore WITec optimized the UHTS spectrometers for specific wavelength ranges. Customers can choose from a variety of focal lengths and gratings to match individual requirements in terms of spectral range and resolution.

SPECTRAL RANGE



03 UHTS 400 UV-VIS

With an optical system tailored for UV measurements, the UHTS 400 UV-VIS is the optimal solution for excitation wavelengths from 355 to 588 nm.

04 UHTS 300 VIS-NIR

Applications requiring broadband excitation from the visible to the near-infrared can greatly benefit from the UHTS 300 VIS-NIR. This spectrometer is well suited for multiple laser configurations between 532 nm and 830 nm while maintaining the advantages of the UHTS series.

01 UHTS 300 VIS

For excitation in the visible range the UHTS 300 VIS provides outstanding dispersive peak separation capabilities. The focal length of 300 mm is in accordance with the required sensitivity for demanding Raman imaging applications.

02 UHTS 600 VIS

The UHTS 600 features an extended focal length of 600 mm for increased spectral resolution, which allows closely adjacent peaks to be resolved more readily. This new addition to the UHTS line enhances spectral resolution without compromising throughput, therefore acquisition times remain unparalleled.

WITec lens-based spectrometers cover the full spectral range with specialized variants, providing the highest throughput for ultra-fast and low light-level Raman imaging applications. All UHTS spectrometers feature an optical fiber port and a software-controlled triple-grating turret. By using high-throughput and high-quality optical components in the beam path, overall sensitivity is significantly improved.

The WITec UHTS series for multiple laser excitation offers the most flexible and advanced solution for hyperspectral Raman microscopy. For individual excitation requirements not listed, WITec can provide a variety of proven and installed spectroscopy solutions. Please discuss your specific needs with the WITec Raman imaging specialists to determine the best configuration for you.

05 UHTS 400 NIR

In the near-infrared regime the use of NIR-optimized optical components is essential for high-throughput spectral acquisition. A focal length of 400 mm, a specialized set of gratings and state-of-the-art deep depletion CCD technology combine to form an ideal solution for NIR Raman spectroscopy.

06 UHTS 300 IR

The UHTS 300 IR covers the excitation range from 800 to 1700 nm, featuring infrared-optimized optical components, gratings and detectors for highly precise and accurate Raman and photoluminescence experiments.

WITec CCD Detectors

Capability, Versatility and Expandability for Raman Spectroscopy – Optimized Today, Ready for Tomorrow

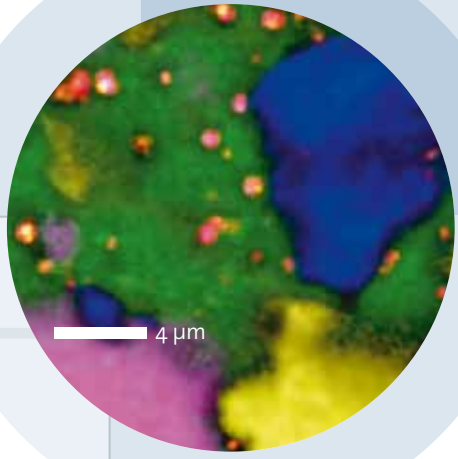
CCD cameras are optimized for certain wavelength ranges, be it UV, visible light or NIR. That must be considered when configuring a UHTS spectrometer setup to meet sophisticated requirements for quick and sensitive Raman imaging. Several types of CCD cameras with quantum efficiencies exceeding 90% can be integrated with the UHTS series.

01 FRONT-ILLUMINATED (FI) CCD

A front-illuminated CCD is characterized by a broad range of possible applications and wavelengths, generally oriented toward budget-conscious but advanced experimental setups.

02 ELECTRON-MULTIPLYING (EM) CCD

Currently, an EM CCD comes as close as possible to an ideal shot noise-limited detector. This type of camera provides the most advanced readout capabilities for low light level detection or ULTRA-FAST RAMAN IMAGING®necessary for sophisticated and leading-edge Raman applications. Readout speed can be as fast as 760 µs per spectrum (1300 spectra/s) and dark current as low as 10^{-4} electrons/pixel/s.



Confocal Raman image of toothpaste. 200 x 200 pixels, 40,000 spectra, acquisition time per spectrum: 760 µs, per image: 40 s.

03 OPEN ELECTRODE (OE) CCD

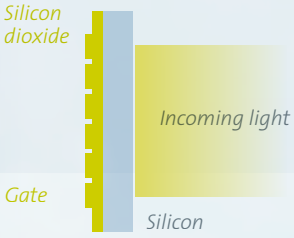
The open electrode CCD is a front-illuminated camera that enables the acquisition of almost the entire spectral bandwidth and is particularly well suited to measurements in the UV. In order to achieve state-of-the-art signal-to-noise ratios it features a low dark-current and multi-purpose camera functionality.

04 LOW DARK-CURRENT DEEP DEPLETION CCD

Near-infrared (NIR) spectroscopic Raman and photoluminescence (PL) measurements require specialized CCD detectors to prevent the spectral data from being influenced by "etaloning," an effect that occurs when the Si-CCD chip materials become increasingly transparent to light at longer wavelengths. With the low dark-current deep depletion technology provided by this detector, critical NIR and PL experiments can be performed with minimal signal loss.

05 BACK-ILLUMINATED (BI) CCD

With a quantum efficiency of 95% or more, back-illuminated CCD cameras set the industry standard for efficient Raman signal detection in the visible range. Compared to a front-illuminated CCD, they offer twice the quantum efficiency and are therefore suitable for precise and sensitive FAST RAMAN IMAGING® at the highest lateral resolution. UV-optimized versions are also available.



06 InGaAs LINEAR ARRAY DETECTOR

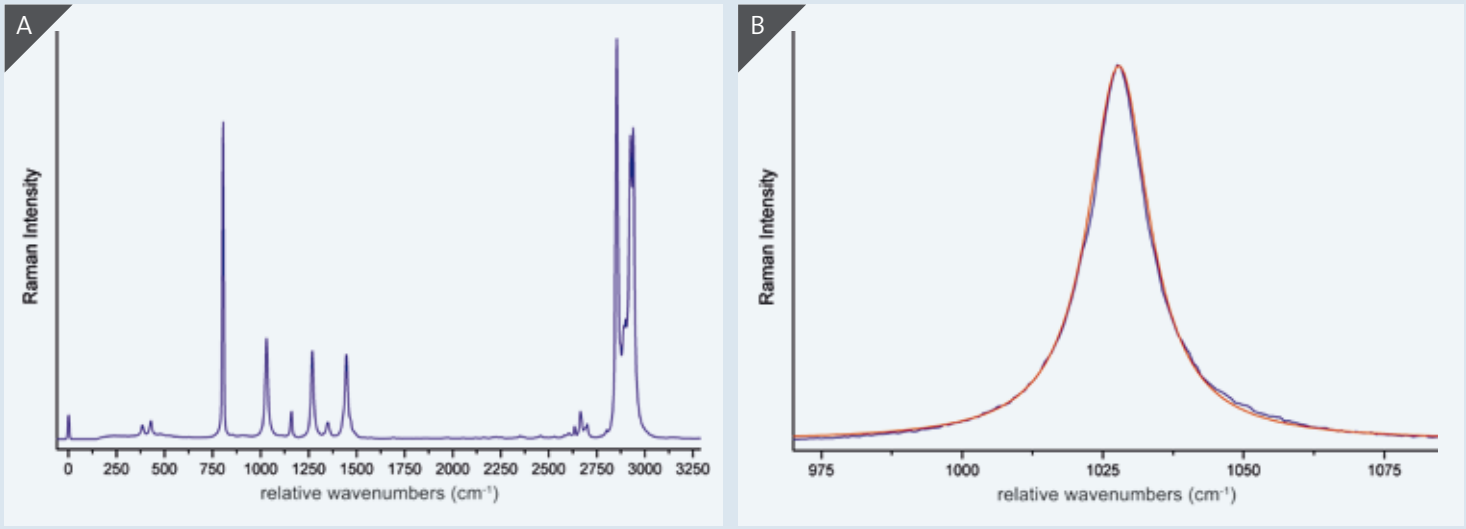
For scattering experiments above the Si-bandgap at approximately 1100 nm, WITec supplies state-of-the-art Indium-Gallium-Arsenide (InGaAs) linear array detectors that allow for spectral imaging in the IR up to 1700 nm with peak quantum efficiencies near 90%.

07 OTHERS UPON REQUEST

Proven Measurement Power
for Demonstrable and Consistent Raman Imaging Results

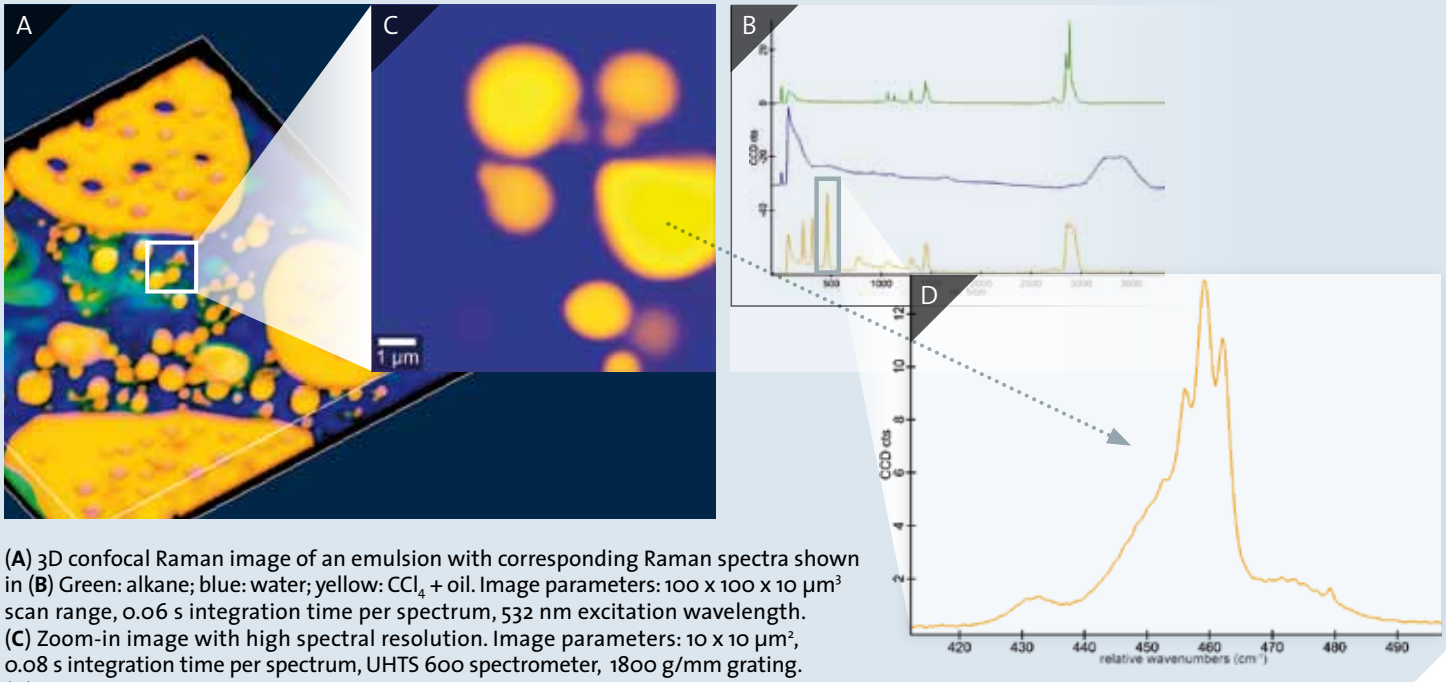
WITec spectroscopic systems enable the acquisition of Raman spectra, images, depth profiles and 3D images with exceptional spectral and spatial precision. This proven performance in speed, sensitivity and resolution is available without compromise or caveat, in your facility.

Symmetric Peak Shape: Cyclohexane



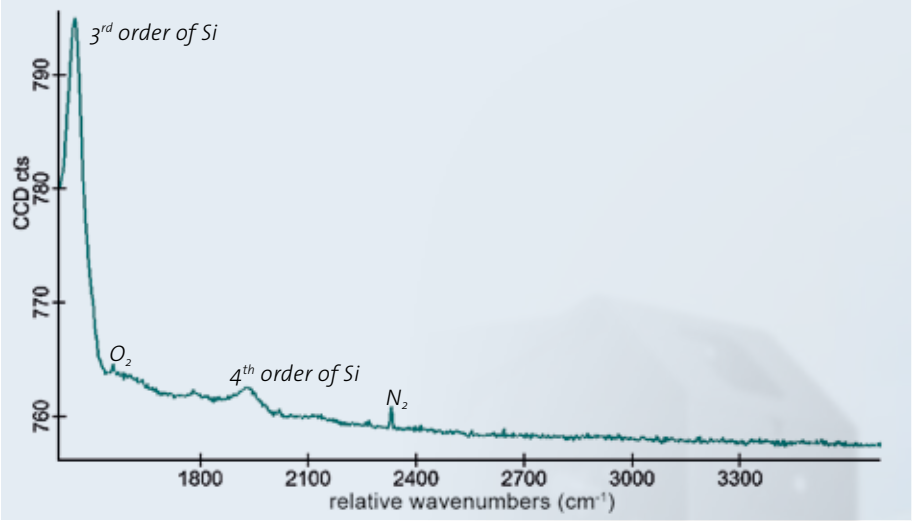
(**A**) Raman spectrum of cyclohexane acquired with the UHTS 300 VIS. (**B**) Zoom-in at the 1030 relative wavenumbers (cm^{-1}) peak region. In addition to the measured spectra (blue) a Lorentzian-fitted curve is displayed (red). The almost perfect match of the measured spectra with the theoretically predicted curve shows the high accuracy of the measurement.

High-performance Raman Imaging Application: CCl_4 – Water-Oil Emulsion



(**A**) 3D confocal Raman image of an emulsion with corresponding Raman spectra shown in (**B**) Green: alkane; blue: water; yellow: CCl_4 + oil. Image parameters: 100 x 100 x 10 µm³ scan range, 0.06 s integration time per spectrum, 532 nm excitation wavelength. (**C**) Zoom-in image with high spectral resolution. Image parameters: 10 x 10 µm², 0.08 s integration time per spectrum, UHTS 600 spectrometer, 1800 g/mm grating. (**D**) Due to the high spectral resolution of the spectroscopic system the CCl_4 bands at around 460 relative wavenumbers (cm^{-1}) can be clearly resolved.

Sensitivity: Raman Spectrum 4th Order of Silicon



The ability to resolve the peak of the 4th order band of Si is widely considered to be a measure of the sensitivity of a Raman spectroscopy system. The spectrum above shows the 4th order Si peak acquired with the UHTS 300 VIS equipped with an EM CCD. No data post-processing other than cosmic ray removal was applied.

The very high signal-to-noise ratio along with the low intensities of the O_2 and N_2 peaks indicate the true confocality of the system as the detected signals from the environment (e.g. air) are extremely low, showing that the contribution from out-of-focus light is effectively blocked by the pinhole.

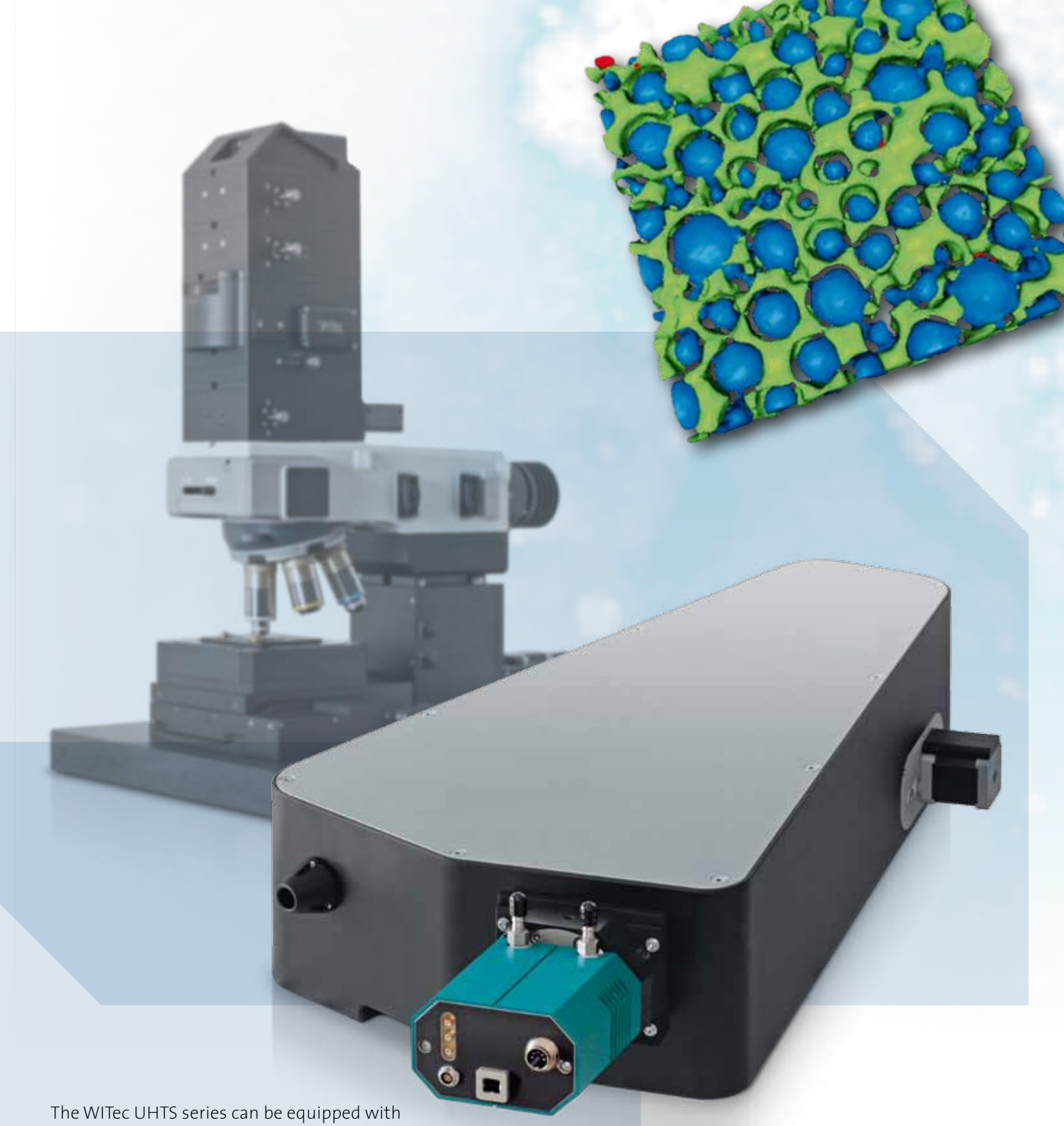
Confocal Raman Imaging

WITec Raman Spectroscopy Solutions

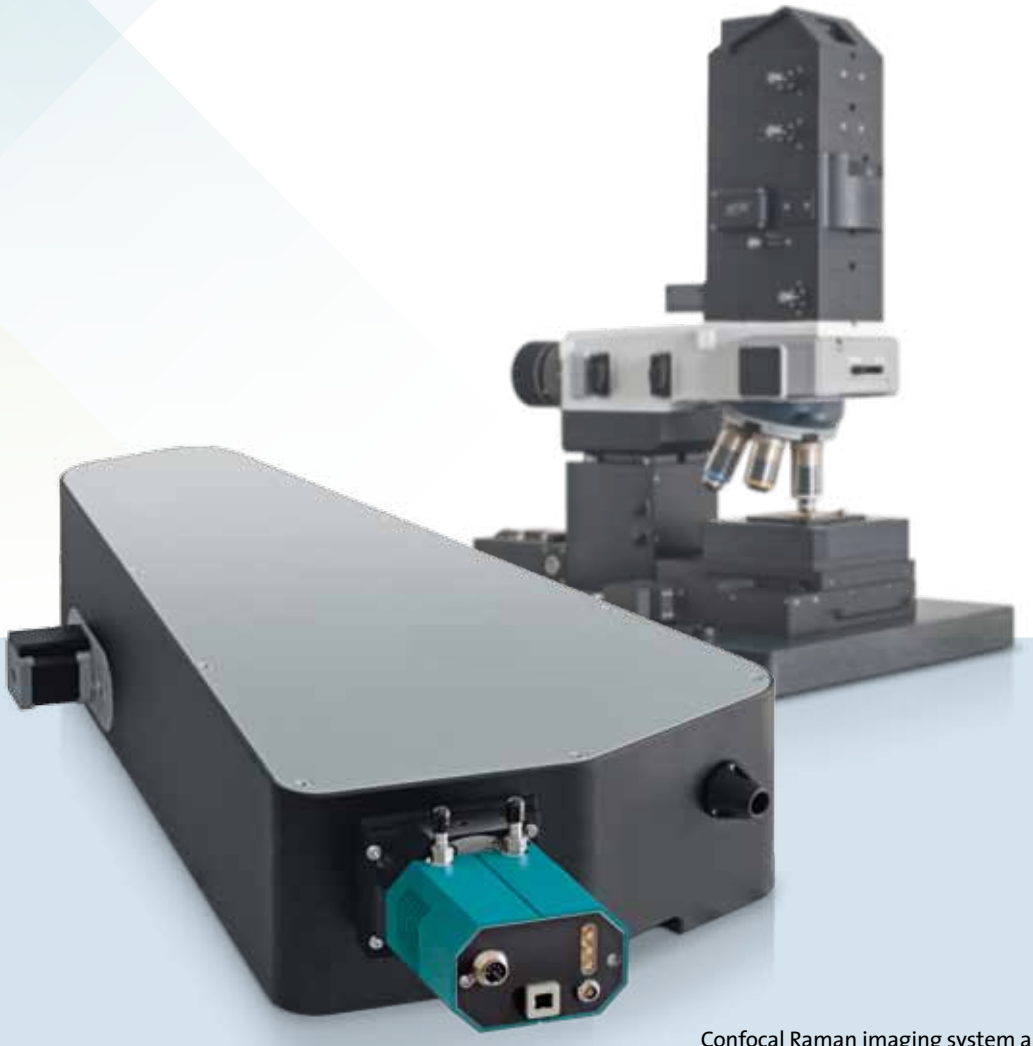
WITec Raman imaging systems combine extremely sensitive confocal microscopes with ultra-high throughput spectrometers for unprecedented capability in chemical characterization. Our Raman imaging specialists are ready to assist in defining an optimized system for individual applications and budget requirements. Even future ambitions can be taken into account as WITec systems are fully upgradeable, scalable and able to incorporate additional excitation wavelengths, scan stages and microscopy techniques. If your scientific approach changes, WITec systems can change with you.

Raman Imaging Benefits

- Detailed analysis of chemical compound distribution, amorphous/crystalline forms and material stress properties
- Lateral spatial resolution down to ~200 nm (diffraction limited)
- 3D chemical imaging due to confocal setup
- Nondestructive
- Minimal, if any, sample preparation required
- Correlative imaging readily available (AFM, SNOM, TERS, SEM)



The WITec UHTS series can be equipped with a selection of market-leading high-quality spectroscopic CCD detectors. With chip sizes and quantum efficiencies matched to the optical components of the spectrometer, setting the benchmark for FAST- and ULTRA-FAST RAMAN IMAGING® has never been easier.



Confocal Raman imaging system alpha300 R
with UHTS 300 spectrometer

WITec Headquarters
WITec GmbH
Lise-Meitner-Straße 6
D-89081 Ulm . Germany
Phone +49 (0) 731 140700
Fax +49 (0) 731 14070200
info@WITec.de
www.WITec.de

WITec North America
WITec Instruments Corp.
130G Market Place Blvd
Knoxville . TN 37922 . USA
Phone 865 984 4445
Fax 865 984 4441
info@WITec-Instruments.com
www.WITec-Instruments.com

WITec South East Asia
WITec Pte. Ltd.
25 International Business Park
#03-59A German Centre
Singapore 609916
Phone +65 9026 5667
shawn.lee@witec.biz

WITec China
WITec Beijing Representative Office
Unit 507, Landmark Tower 1
8 North Dongsanhuan Road
Beijing, PRC., 100004
Phone +86 6590 0577
shuo.ding@witec-instruments.com

WITec Japan
WITec K.K.
KSP W713B Sakado 3-2-1 Takatsu-ku
Kawasaki-shi Kanagawa 213-0012
Japan
Phone +81 44 819 7773
keiichi.nakamoto@witec-instruments.biz